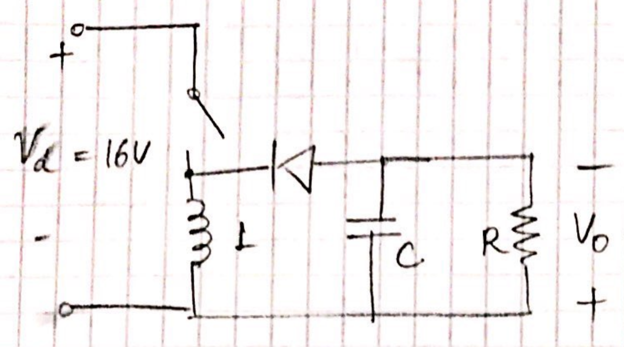
EE464 HW1

Q1 | Buck – boost converter.



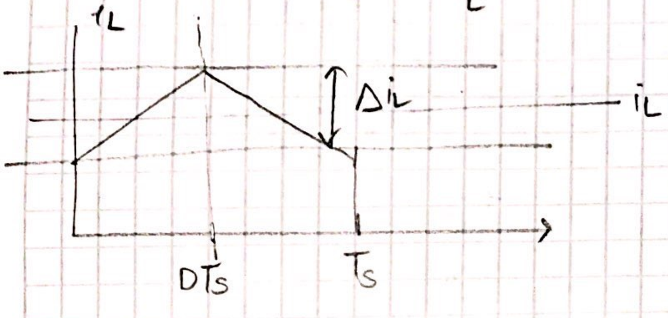
✓ $f_s = 50kHz$

✓ 24W

✓ $\frac{\Delta V_o}{V_o} \leq 0,02$

$\frac{12}{16} = \frac{D}{1-D} \rightarrow 12 - 12D = 16D$ $\quad \boxed{D = \frac{3}{7}}$

a) L so that $\frac{\Delta i_L}{i_L} = 0,1$?



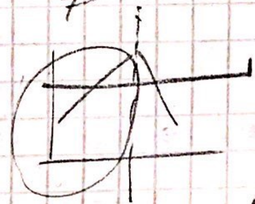
$v_L = L \frac{di_L}{dt}$

since the waveform is linear,

$\frac{V_L}{L} = \frac{\Delta i_L}{\Delta t} \rightarrow \Delta i_L = \frac{V_L \Delta t}{L}$

During the on cycle, the inductor will be charged. Assuming that it charges up with $i_{in\,ave}$ will be misleading. To find $i_{L\,ave}$, treat i_{in} as if it was nonzero for the entire period. $\rightarrow i_{L\,ave} = \frac{i_{in\,ave}}{\frac{3}{7}} = \frac{\frac{3}{2}}{\frac{3}{7}} = \boxed{3,5}$

we know $\Delta i_L = 3,5 \cdot 0,1 = \boxed{0,35\,A}$



our point of interest. Here, $i_{in} = i_L$. so, treat i_{in} to be nonzero across the entire period.

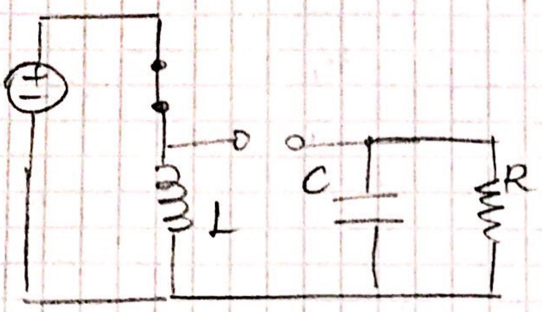
Also, $\Delta i_L = i_L(t_{on}) - i_L(0)$

$= \frac{16V \cdot 3}{7 \cdot 50kHz \cdot L} = 0,35$

$L = \frac{48}{0,35 \cdot 350k} \cong \boxed{0,392\,mH}$

b) C so that $\frac{\Delta V_{out}}{V_{out}} = 0{,}02$?

Consider the ON cycle:



$i_o = \frac{24W}{12V} = 2A$

The capacitor will supply the output.
Assuming a constant current at the output

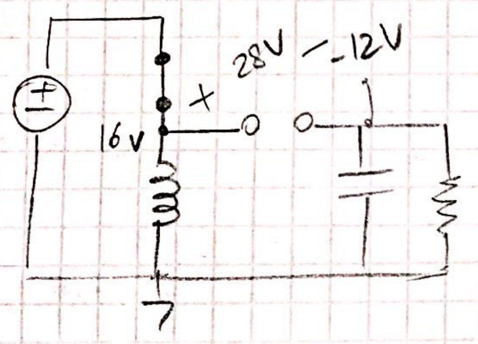
$i_o = C \frac{\Delta V_c}{\Delta t}$

$2A = C \cdot \frac{\Delta V_o}{(D\,T_s)}$ $\quad \frac{\Delta V_o}{V_o} = 0{,}02 \rightarrow \Delta V_o = 0{,}24$

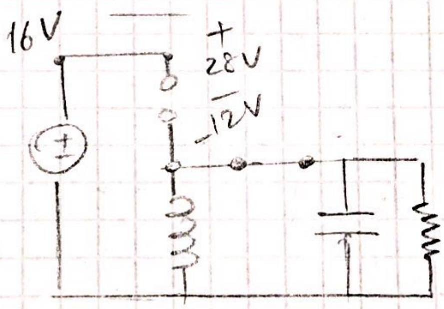
$C = \frac{2 \cdot 3}{7 \cdot 50k \cdot 0{,}24} \cong \boxed{71{,}43 \mu F}$

c) Choose commercial products. → SW, L, C, D

ON



OFF



→ D should be able to withstand − 28 V.

→ D should be able to carry 2A current.

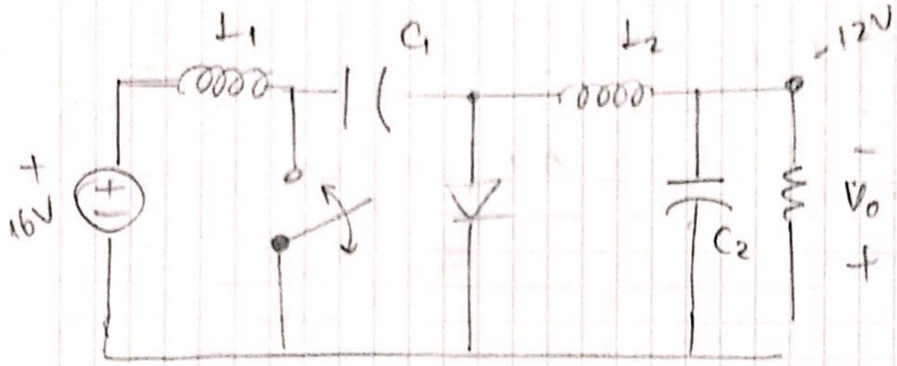
→ The switch needs to allow an average current of $\frac{4}{3}$A.

→ The switch needs to be able to withstand 28V.

- L → watch out for the current rating : 3,5A ± 0,05% $\cong$ 3,675 A_{peak}
- C → watch out for the voltage rating : 12V ± 0,01% = 12,12 V_{peak}

Scanned with CamScanner

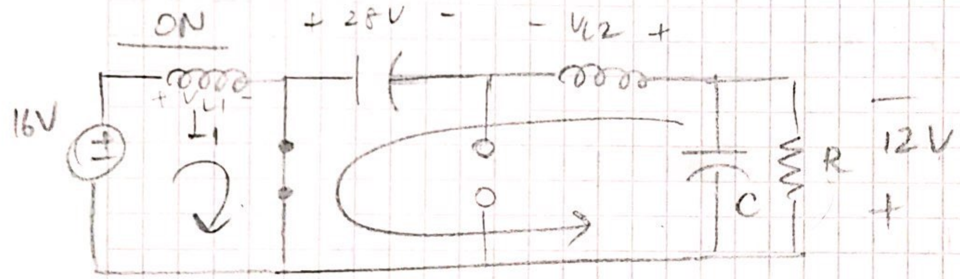
Q2| Ćuk Converter



a) Find C_2 by assuming 2% ripple and L_1 and L_2 by assuming 10% ripple.

Once again, $\frac{V_0}{V_d} = \frac{D}{1-D}$, so the duty remains identical.

$24W = 16\, i_{in\,ave} = 12\, i_{out\,ave}$ $\begin{cases} i_{in\,ave} = \frac{3}{2}A \\ i_{out\,ave} = 2A \end{cases}$



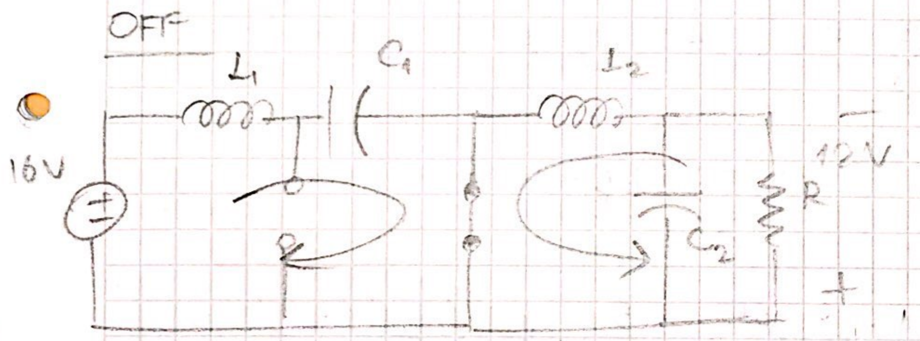
L_2/ this inductor will see a voltage of +16V.

$$\Delta i_{L_2} = \frac{16V \cdot 3}{7 \cdot 50kHz \cdot L_2}$$

$$\frac{\Delta i_{L_2}}{i_{L_2}} = \frac{\cancel{48}^{24}}{350k \cdot L_2 \cdot \cancel{2}} = \frac{1}{10}$$

$$L_2 = \frac{240}{350k}$$

$$\boxed{L_2 \cong 0{,}686mH}$$



L_1/ this inductor will see a voltage of +16V during the on cycle.

$$\Delta i_{L_1} = \frac{16V \cdot 3}{7 \cdot 50kHz\, L}$$

$$\frac{\Delta i_{L_1}}{i_{L_1}} = 0{,}1 \Rightarrow \frac{\cancel{48V}^{16}}{350k \cdot L_1 \cdot \frac{\cancel{3}}{2}} = \frac{1}{10}$$

$$\frac{320}{350k} = L_1$$

$$\boxed{L_1 \cong 0{,}914mH}$$

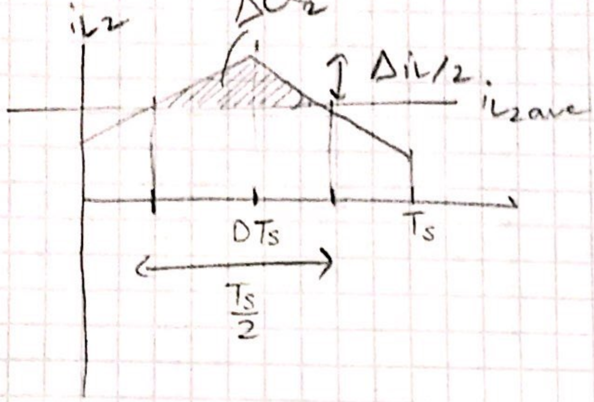
> verify in the discharge cycle:

$$\Delta i_{L_1} = \frac{(16-28) \cdot 4}{7 \cdot 50kHz\, L_1}$$

$$\boxed{\cong 0{,}150\,A\ ✓}$$

$L_1 = 0{,}914\ mH$

We can find the V_{c2} ripple by considering the i_{L2} waveform.



$$\Delta Q_2 = \frac{\Delta i_{L2}}{2} \cdot \frac{T_s}{2} \cdot \frac{1}{2}$$

$$\Delta V_o = \frac{\Delta Q_2}{C} = \frac{\Delta i_{L2} T_s}{8 C_2}$$

$$\Delta V_o = \frac{(1-D)\, T_s\, (-V_o)\, T_s}{8 L_2 C_2}$$

$$\left|\frac{\Delta V_o}{V_o}\right| = \frac{(1-D)\, T_s^2}{8 L_2 C_2} = 0{,}02$$

$$\frac{4 \cdot 1000}{7 \cdot (50k)^2\, 8 \cdot 0{,}686 \cdot C_2} = 0{,}02$$

$$\rightarrow \boxed{C_2 \cong 2{,}082\ \mu F}$$

b) Find C_1 if $\frac{\Delta V_{c1}}{V_{c1}} = 0{,}1$

During the off cycle, L_1 discharges and C_1 charges.

> Assume it charges w/ a constant I_{L1ave}.

Then, $\frac{\Delta V_{c1}}{\Delta t} \cdot C_1 = i_{c1} = i_{L1ave}$

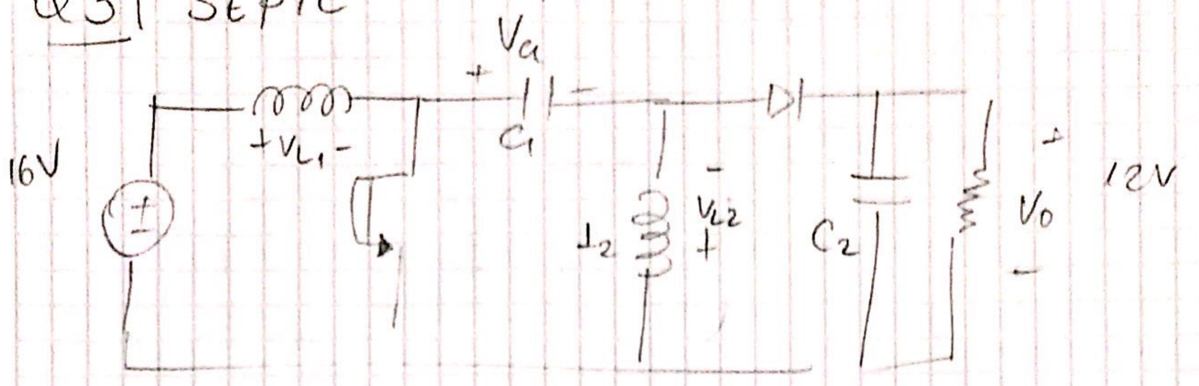
$$\Delta V_{c1} = \frac{(1-D)\, T_s \cdot 1{,}5A}{C_1}$$

$$\frac{\Delta V_{c1}}{V_{c1}} = \frac{4}{7} \cdot \frac{1}{50k} \cdot \frac{3}{2} \cdot \frac{1}{C_1} \cdot \frac{1}{28} = \frac{1}{10}$$

$$\rightarrow C_1 = \frac{120}{350k \cdot 56}$$

$$\rightarrow \boxed{C_1 = 12{,}45\ \mu F}$$

Q3| SEPIC



> same duty, once again. $(D = \frac{3}{7})$
(same transfer function)

$i_{L1ave} = \frac{3}{2} A$

a) L_1 and L_2 assuming 10% ripple?
C_2 assuming 2% ripple?

ON cycle → L_1 charges w/ $V_s = 16V$.

$$\Delta i_{L_1} = \frac{16 \cdot 3}{7 \cdot L_1 \cdot 50k} = 0{,}15 \rightarrow \boxed{L_1 = 0{,}914 \text{ mH}}$$

L_2/ In the off cycle, $i_D = i_{in\,ave} + i_{in\,out}$. This implies $i_{L2\,ave}$ must be $i_{out\,ave}$.

In the on cycle, i_{L2} will increase w/ $V_{a_{ave}} = V_s = 16V$

$$\Delta i_{L_2} = 0{,}2 = \frac{16 \cdot 3}{7 \cdot L_1 \cdot 50k} \longrightarrow \boxed{L_2 = 0{,}686 \text{mH}}$$

C_2/ In the on cycle, C_2 will supply the output current
Assuming it to be constant at 2A.

$$\Delta V_o = \frac{2A \cdot 4}{7 \cdot C_2 \, 50k} = 0{,}24 \rightarrow \boxed{C_2 = 95{,}238 \, \mu F}$$

b) C_1 assuming $\Delta V_a = 1{,}6$?

> in the on cycle, it will discharge to feed L_2.
Assuming a constant current of 2A (i_{L2ave})

$$\Delta V_a = \frac{2A \cdot 3}{7 \cdot 50k \, C_1} = 1{,}6 \rightarrow \boxed{C_1 \cong 10{,}71 \, \mu F}$$